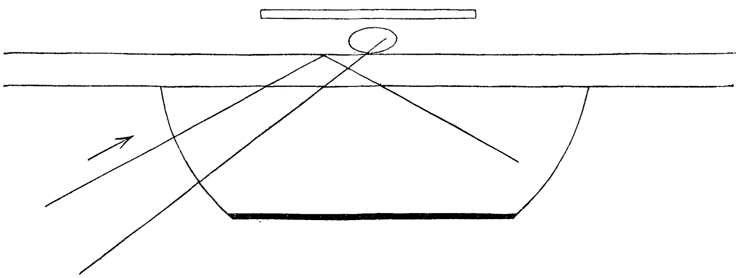
due, in no small degree, to the recurrent ice action of the northern hemisphere, so close is the connection between this most destructive agent and the highest life.

THE NEW IMMERSION ILLUMINATION.

BY R. H. WARD, M.D.

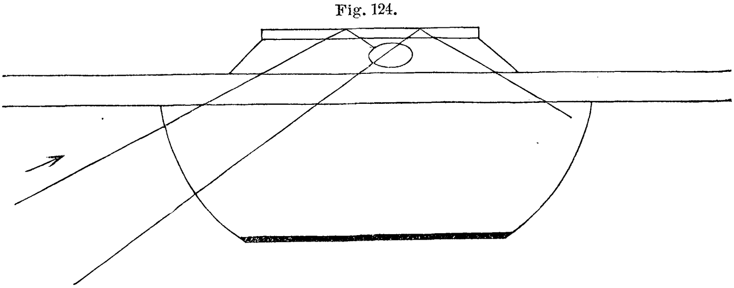
THE new illuminating lens, introduced by Mr. Wenham recently, has proved to be a sufficiently important accessory to the microscope to command more attention than it has yet received in this

Fig. 123.



country. A small plano-convex lens, nearly hemispherical, has the central part of its curvature stopped off with black varnish; and for convenience the part intended to be thus suppressed

Fig. 124.

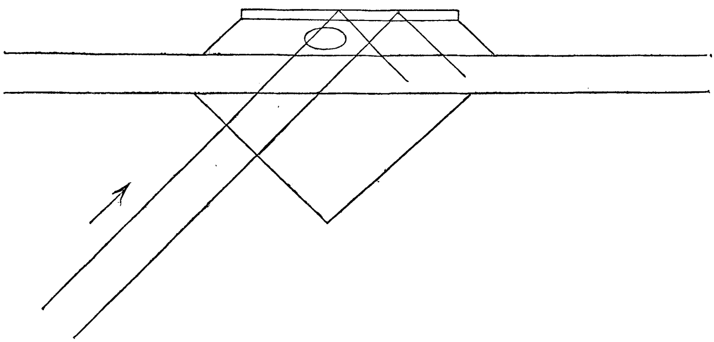


may be ground away as shown in Figs. 123 and 124, the ground surface being subsequently painted black. The lens thus prepared is temporarily attached by some highly refracting medium, such as

glycerine or oil of cloves, to the under surface of the slide. It becomes, manifestly, an immersion spotted lens; though it has lost so much of its angular aperture, to say nothing of the difficulty of placing the object in its focus, that it can no longer be used as such. Its available action is that of enabling us to throw light obliquely into the slide at such an angle, ordinarily impracticable, that it shall suffer total internal reflection from the top of the slide (Fig. 123), or from the top of the glass cover when that is optically identified with the slide, as when we examine an object in balsam, glycerine, etc. (Fig. 124).

For many years our best means of producing this effect was a prism, as shown in Fig. 125. A small prism is attached to the under surface of the slide, temporarily, by soft balsam or by oil or glycerine in the case of mounted specimens, or permanently,

Fig. 125.



by balsam to a blank slide which is to be used for the occasional examination of unmounted specimens. This arrangement gives so little light, and so little control of the angles at which the light meets the axis of the object and the axis of the instrument, that it has been but little used and with indifferent results.

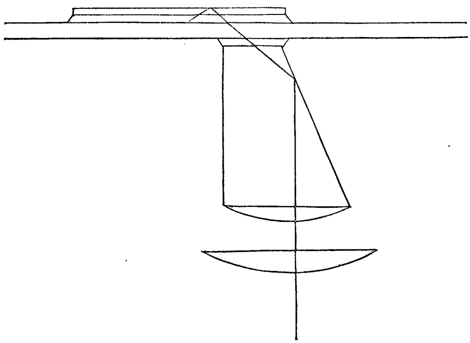
Mr. Wenham's lens removes all these difficulties. It is easy to get light enough for moderately high powers; and the light can be thrown upon the object at a considerable range of angles and from any side or from all sides at once. When light is to be supplied from one side only, it may be directed by a rectangnlar prism or a Reade's prism, or an (inclined) achromatic condenser of long focus and small angle—such as a two-inch or three-inch objective; while from all directions at once it is best supplied by the common glass paraboloid. The latter effect may be obtained, as explained

by Prof. Biscoe, by the common paraboloid alone, it being converted into an immersion instrument by filling its cup with water.

These means of illumination, now for the first time available, may act in three distinct ways, one of which is new.

The new method is applicable only to objects mounted dry, and is illustrated by Fig. 123. It has been called, by Rev. S. Leslie Brakey, Internal Illumination. All the light suffers total internal reflection from the upper surface of the slide except that which meets the surface at the points of contact of the object, and the rays thus excepted enter and illuminate the object. Of course the object must lie upon the slide, and beginners are often puzzled by

Fig. 126.



failure, not suspecting or remembering that the object may have been mounted upon the under surface of the cover.

The two other methods are the common opaque illumination and dark-field illumination, which are illustrated together in Fig. 124, as they are usually employed together in practice. They are applicable only to objects mounted in some medium, in which case the top of the cover becomes, optically, the first surface reached by the light after entering the lens. The upper ray in Fig. 124 represents this method of opaque illumination, the ray being reflected by the cover upon the object. The lower ray represents the dark-field effect, the object being illuminated precisely as by the common paraboloid, only the field is darkened not by the obliquity of the rays passing through the cover but by the fact that they are reflected back by it.* Hence its greater complete-

* This illumination is not exactly represented in the diagram. Most of the light reflected down by the cover is that which passes by the side of the object, and not that which passes through the object. This is shown in Fig. 125, but simplified in Fig. 124.

ness and its applicability to large angular apertures. Its effect is superb with powers as high as $\frac{1}{8}$ of 130° or 140°, especially when used with the binocular.

In practice it is not easy, nor often necessary, to separate the latter two methods. They separate themselves according to the character of the object. With an absolutely opaque object the opaque illumination will alone be accomplished, the dark-field effect (lower ray of Fig. 124) being necessarily suppressed; and success will probably be difficult and only indifferently good. With sufficiently translucent objects the opaque effect would be insignificant, but the dark-field effect easy and excellent. Objects just opaque enough to answer equally to both methods give a confused result, which might possibly be valuable in exceptional cases.

The latest contrivance (Mr. Wenham's, of course) for an immersion illuminator is a glass cylinder half an inch long, one side of which is ground off at an angle of 64° and polished to furnish an internally reflecting surface. The upper end approaches the bottom of the object slide, the interval being filled with water as in the use of an immersion lens, and the lower end is ground to a convex surface whose refracting effect on the pencil of light is supplemented by a plano-convex lens placed below it. In fact we have something like a Wollaston's doublet for a condenser, whose cone of light is twice bent by internal reflection so that its apex is in the position of the object between the cover and the slide. In the diagram (Fig. 126) only a central ray is represented; but in use nearly all the light falling upon the lower lens is brought to a focus on the object, giving an abundance of light and remarkable results with high powers. The apparatus is so mounted on the sub-stage as to rotate around its own focal point as a centre; and excels the former appliances in giving a more intense one-sided illumination, in confining the light to the object instead of lighting up everything in the neighborhood, and in allowing the slide to be moved or changed with facility.

Immersion achromatic condensers for transparent (bright-field) illumination have not yet received sufficiently extensive trial to ascertain their exact degree of usefulness; but they seem likely to come into use as a means of increasing the available angular aperture of immersion objectives, if not for other purposes.